

How Stormwater Bioretention Captures PCBs

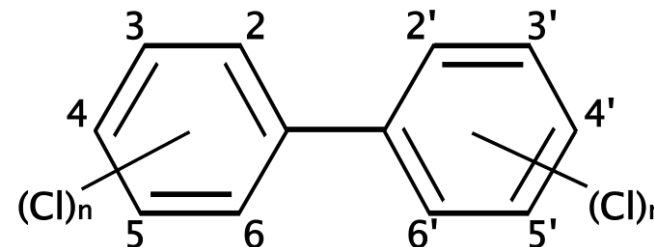
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PCBs - What are they?

- Banned in 1977 but remain in many existing in-use materials
- 209 different forms called congeners
 - Homologs are groups of PCBs with the same of chlorine atoms
 - E.g. There are 31 different pentachlorinated PCB congeners all having 5 chlorines, while there are 23 different trichlorinated PCB congeners each containing 2 chlorines.
 - PCB Congeners are often grouped by homolog group as they often behave similarly
- Semi-volatile
- Attracted to organic carbon; dis-like being dissolved in water



Why do we care?

- Highly toxic
- Responsible for most Washington fish advisories
 - High toxicity while highly bioaccumulative = very low water quality standard of 7 pg/L (parts per quadrillion)
- Raise awareness about the need to validate stormwater management BMPs for PCBs in general
- If year over year PCB capture remains high, at what point might bioretention facilities become dangerous waste?
- If year over year PCB capture is not as high, will bioretention be effective at interrupting urban cycling of PCBs before they reach waterbodies?

Bioretention Soils Effectiveness Questions?

- What is the PCB removal (capture) rate in BSM, and does it vary by congener? (within one storm)
- What is the wet season PCB sequestration (retention over multiple storm events) in BSM, and does this vary by congener?
- What is the PCB retention in BSM during the dry season, and does it vary by congener?

Mesocosm scale study using I-5 runoff



Mesocosms setup in triplicate

- 55 gallon stainless steel drums
- Gravel plus 18 inches of 60:40 (Sand:Compost) BSM
 - ~3 inches of wood chip mulch
- Pacific Ninebark in 3, while 3 had no plants
 - Note: Bare root Ninebarks were very small to start
- 20:1 impervious surface to infiltration area design ratio



Data collected over 25 months

- Although paired with USFW/WSU studies addressing toxicity and fungi, this investigation only used the “Soil Only” and “Soil Plus Plants” mesocosms
- Quarterly soil samples
 - Composite cores
- Quarterly storm samples
 - 2 hour composites
- Flow



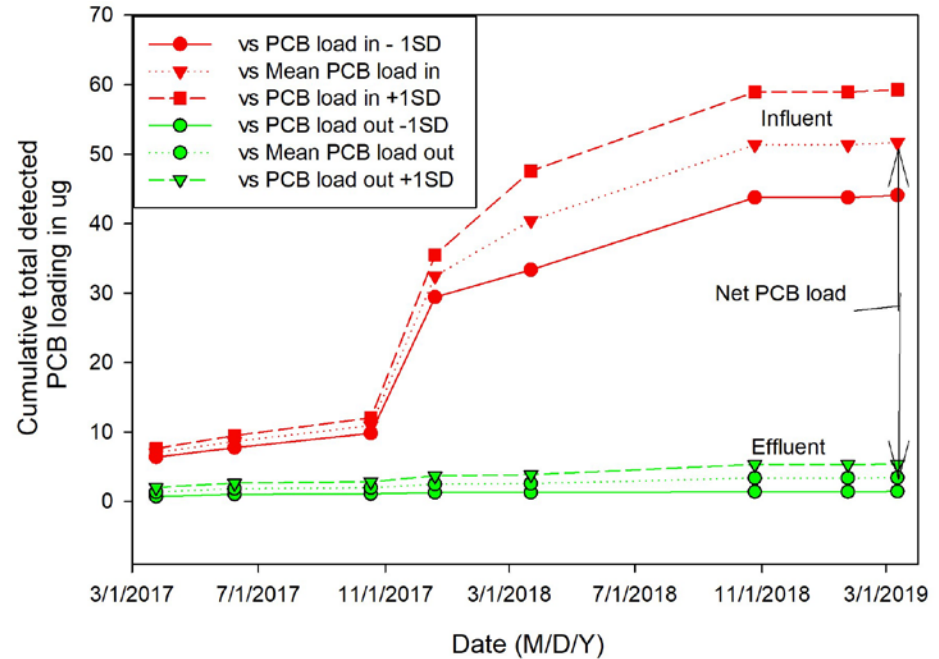
Treatment effectiveness

- **BSM is highly effective at removing PCBs**
 - Effluent does not meet 7 pg/L water quality standard, but vastly improved
 - Plants not important
 - No change in effectiveness over 25 months
- Treatment efficacy is high across all congener groups

PCB Homolog Group	mean influent pg/L	mean effluent pg/L	mean % removal via BSM
1	0.8	0.1	90.4
2	67.2	13.5	79.5
3	209.8	5.0	96.1
4	743.5	47.5	90.6
5	1097.6	126.6	86.1
6	1144.1	95.8	88.8
7	316.6	31.1	88.2
8	57.2	5.8	72.2
9	11.6	<0.0	99.9+
10	4.8	1.4	37.3*
Sum of all homologs	3,653	184	90.7

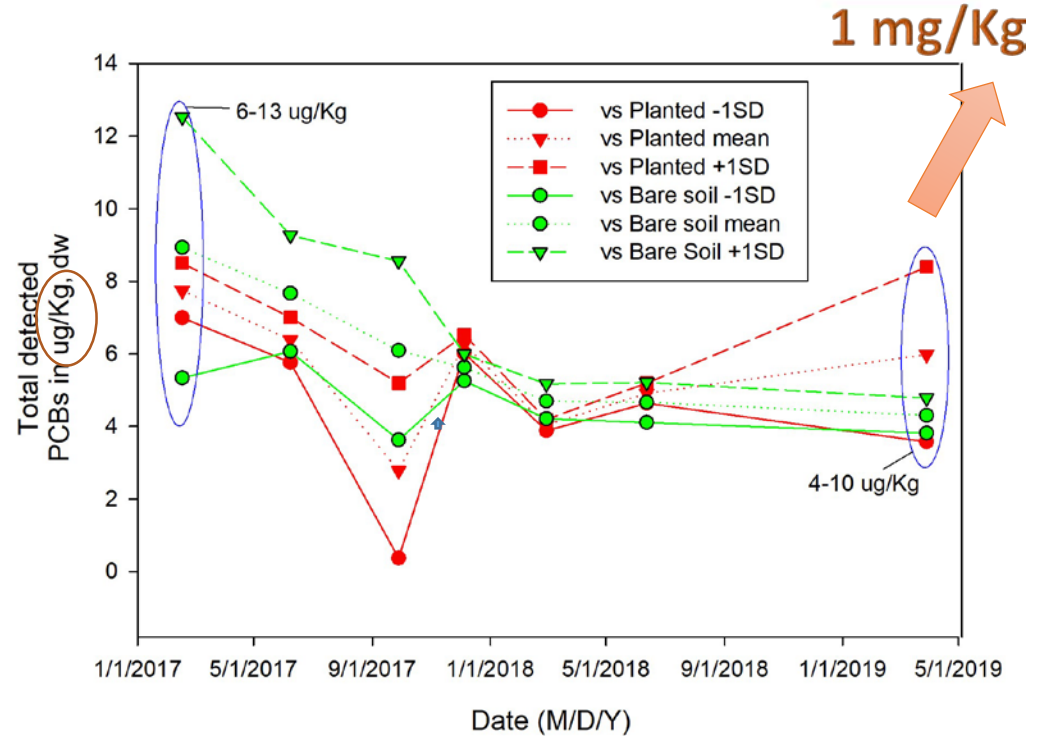
Water loadings

- ~50 μg PCBs load over 2 years
- About 3.5 μg exported over 2 years
- **Vast majority of PCBs are sequestered in BSM**
- Is this accumulation going to be a problem?



Soil accumulation?

- Potentially relevant *decline* in soil PCB concentrations over time
- ~10 $\mu\text{g}/\text{Kg}$ is 1% of the 1 mg/Kg regulatory threshold for PCBs in soils
- Accumulation to regulated levels would take 100s of years



So where do the PCBs go?

- High capture rate
- Don't appear to be accumulating suggests one of two options (or a little of both)
 - 1) They're offgassing
 - 2) They're degrading
- Study wasn't sufficiently powered or capable of distinguishing these
 - BSM environment is highly biologically active
 - PCB loads are small enough to not be limiting the growth of degrading organisms
 - White rot fungi were abundant and some strains are known PCB degraders
- Bench scale tests with labelled PCB congeners would be an appropriate strategy to examine these options

Bioretention Soils Study Answers?

- What is the PCB removal (capture) rate in BSM, and does it vary by congener?

High! BSM makes significant progress towards WQS

- If year over year PCB capture remains high, at what point might bioretention facilities become dangerous waste?

Not for 100s of years

- Are PCBs just recycling from BSM back into the urban environment?

Probably degrading, but needs more study



Questions?

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